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PATENT APPLICATION

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CAMERON BOLITHO BROWNE et al.	)	
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For: METHOD AND APPARATUS FOR	)	
ORIENTATING A CHARACTER	:	
STROKE	)	April 22, 2005

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SUBMISSION OF PRIORITY DOCUMENT

Sir:

In support of Applicants' claim for priority under 35 U.S.C. § 119 in the above-identified application, the Issue Fee for which is due to be paid July 7, 2005, enclosed is a certified copy of the following foreign application:

Australian Patent Application No. PP 5578, filed August 28, 1998.

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Applicants' undersigned attorney may be reached in our Costa Mesa, CA office at (714) 540-8700. All correspondence should continue to be directed to our address given below.

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I, KIM MARSHALL, MANAGER EXAMINATION SUPPORT AND SALES, hereby certify that the annexed is a true copy of the Provisional specification in connection with Application No. PP 5578 for a patent by CANON KABUSHIKI KAISHA filed on 28 August 1998.

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WITNESS my hand this Twelfth
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KIM MARSHALL
MANAGER EXAMINATION SUPPORT AND SALES

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S & F Ref: 409199

ORIGINAL

AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION FOR THE INVENTION ENTITLED:

Method and Apparatus for Orientating a Character Stroke

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Name of Inventors: Cameron Bolitho Browne and Michael Richard Arnold

This invention is best described in the following statement:

5805

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METHOD AND APPARATUS FOR ORIENTATING A CHARACTER STROKE

Field of Invention

The present invention relates to a method and apparatus for orientating a character stroke. The invention also relates to a computer program product including a computer readable medium having recorded thereon a computer program for orientating a character stroke. The invention further relates to a method and apparatus for orientating a n-dimensional finite space curve, including a computer program product therefor.

Background of Invention

United States Patent No. 5,771,035 discloses a character generation device for producing new fonts from a basic font and paste components. The device has a shape recognisor for extracting an element of a character of the basic font and recognising it's shape. The shape recognisor determines the stroke angle of the element and the paste components are superposed at the angle matching the angle of the stroke. The device allows the easy generation of characters of a font without manually designing each character. However, this device suffers from the disadvantage that it is not possible to manipulate the stored basic font, particularly the orientation of character strokes.

Aspects of Invention

It is an object of the present invention to ameliorate one or more disadvantages of the prior art.

One or more exemplary aspects of the invention are listed below, but are not limited thereto.

According to one aspect of the invention there is provided a method of orientating a character stroke, the method including the following steps:

(i) selecting a desired direction in response to user input;

(ii) generating a second vector having an associated direction in the same direction as the selected direction;

(iii) providing a character stroke;

(iv) generating at least one first vector having an associated direction indicative of a characteristic of the character stroke;

(v) determining that direction of the character stroke nearest to said desired direction in accordance with said first and second vectors; and

(vi) orientating said character stroke to the determined direction.

According to another aspect of the invention there is provided a method of orientating a finite n-dimensional space curve, the method including:

(i) selecting a desired direction in response to user input;

(ii) generating one or more second vectors based on the selected direction;

(iii) providing a said finite n-dimensional space curve;

(iv) generating one or more first vectors based upon the finite n-dimensional space curve;

(v) determining that direction of the finite n-dimensional space curve nearest to said desired direction in accordance with said first and second vectors; and

(vi) orientating said finite dimensional space curve to the determined direction.

According to still another aspect of the invention there is provided an apparatus for orientating a character stroke, the apparatus including:

means for selecting a desired direction in response to user input;

means for generating a second vector having an associated direction in the same direction as the selected direction;

means for providing a character stroke;

means for generating at least one first vector having an associated direction indicative of a characteristic of the character stroke;

means for determining that direction of the character stroke nearest to said desired direction in accordance with said first and second vectors; and

means for orientating said character stroke to the determined direction.

According to still another aspect of the invention there is provided an apparatus for orientating a finite n-dimensional space curve, the apparatus including:

means for selecting a desired direction in response to user input;

means for generating one or more second vectors based on the selected direction;

means for providing a said finite n-dimensional space curve;

means for generating one or more first vectors based upon the finite n-dimensional space curve;

means for determining that direction of the finite n-dimensional space curve nearest to said desired direction in accordance with said first and second vectors; and

means for orientating said finite dimensional space curve to the determined direction.

According to still yet another aspect of the invention there is provided a computer program product including a computer readable medium having recorded thereon a computer program for orientating a character stroke, the computer program product including:

means for selecting a desired direction in response to user input;

means for generating a second vector having an associated direction in the same direction as the selected direction;

means for providing a character stroke;

means for generating at least one first vector having an associated direction indicative of a characteristic of the character stroke;

means for determining that direction of the character stroke nearest to said desired direction in accordance with said first and second vectors; and

means for orientating said character stroke to the determined direction.

According to still further aspect of the invention there is provideda computer program product including a computer readable medium having recorded thereon a

computer program for orientating a finite n-dimensional space curve, the computer program product including:

means for selecting a desired direction in response to user input;

means for generating one or more second vectors based on the selected direction;

means for providing a said finite n-dimensional space curve;

means for generating one or more first vectors based upon the finite n-dimensional space curve;

means for determining that direction of the finite n-dimensional space curve nearest to said desired direction in accordance with said first and second vectors; and

means for orientating said finite dimensional space curve to the determined direction.

Brief Description of the Drawings

Embodiments of the invention are described with reference to the drawings, in which:

Fig. 1 is a flow diagram of a method of orientating an n-dimensional finite space curve in accordance with a preferred embodiment of the invention;

Fig. 2 illustrates an example 2-dimensional curve with end points labelled;

Fig. 3 illustrates an example set of two preferred direction vectors for the 2-dimensional case;

Fig. 4 illustrates an example set of three preferred direction vectors for the 3-dimensional case;

Figs. 5A and 5B illustrate vectorial relationships between the curve end points;

Figs. 6A and 6B illustrate the relationship between end point vectors and the preferred direction vector;

Figs. 7A to 7F illustrate the special case of ambiguous orientation and its solution using the second preferred direction vector;

Fig. 8 illustrates the special case of coincident start and end points for a closed curve;

Fig. 9 illustrates a variety of 2-dimensional curves oriented to various preferred directions;

Fig. 10 illustrates an example 2-dimensional curve with end points and end tangent directions shown;

Fig. 11 illustrates an example preferred direction vector for the 2-dimensional case;

Figs. 12A and 12B illustrate the relationship between end tangent vectors and the preferred direction vector;

Fig. 13 illustrates the special example of parallel end tangent vectors;

Figs. 14A to 14D illustrate a solution to the problem shown in Fig. 12 based on end point position;

Figs. 15A to 15F illustrate the resolution of the ambiguous end point case using a second preferred direction;

Fig. 16 illustrates the special case of coincident start and end points for a closed curve;

Fig. 17 illustrates a variety of 2-dimensional curves oriented to various preferred directions; and

Fig. 18 is a block diagram of a general purpose computer with which the embodiments can be implemented;

Detailed Description

Where reference is made in any one or more of the drawings to steps and/or features, which have the same reference numerals, those steps and/or features are for the purposes of the description the same, unless the contrary appears.

The principles of the preferred method have general applicability to n-dimensional finite space curves. However, for ease of explanation, 2-dimensional examples are also described, in particular the orientation of 2-dimensional curves that

describe the paths of stroke-based typeface characters. It is not intended that the present invention be limited to these 2-dimensional examples.

Fig. 1 is a flow diagram of a method of orientating a n-dimensional finite space curve in accordance with a preferred embodiment of the invention. The preferred method allows orientation of a space curve in a simple and consistent manner with limited user input. The method commences at step 102 and any necessary processes and parameters are initialized. In the next step 104, the user selects a desired direction for orientating the n-dimensional finite curve space. The processing continues at the next step 106, where a second vector having the same direction as the desired direction is generated. Also during this step, n-1 additional second vectors are generated from the desired direction supplied by the user. Each of these additional second vectors is non-zero and is linearly independent of the other second vectors, thus forming a basis. Alternatively, the user may input each desired direction of these additional vectors. In this way, any ambiguous result of orientating the space curve can be resolved. In the next step 108, an n-dimensional finite space curve is provided, which may be accessed from memory or may be implicitly generated. The processing continues at the next step 110, where one or more first vector(s) based upon a characteristic of the space curve are generated. Preferably, the method automatically generates the first vector(s) according to a predetermined technique. Alternatively, the method can include a step (not shown) whereby a user is able to select the desired technique for generating the first vector(s). These techniques and some typical examples of first vectors are given in the examples described below. In the next step 112, a comparison is made between the two first vectors and the initial second vector to determine that direction of the space curve closest to the desired direction. If both first vectors are equally close then the additional second vectors are utilized to resolve the ambiguity. In step 114, the n-dimensional finite space curve is then orientated to that direction determined by step 112. In the decision box 116, a check is made whether any more space curves are to be processed. If the decision box returns true, the processing continues at step 108.

Otherwise, the processing terminates at step 118. For a more detailed explanation of the preferred method reference is made to the following examples.

Example(s)

Turning initially to Fig. 2, there is shown a sample 2-dimensional space curve describing the stroke path 21 of the character "S". Two end points A 22 and B 23 have been labelled, and the curve is not oriented at this stage. The end points are selected such that all points along the curve lie within the interval formed by these end points. This 2-dimensional curve is derived from a complex character shape "S". Any of the known algorithms for obtaining the stroke path from the character shape would be suitable. This complex character shape may be stored in memory for processing by the preferred method. Alternatively, the complex character shape may be implicitly generated.

Turning to Fig. 3, there is shown the "preferred vector" v1 31 that describes an angle theta 32 with the X-axis. The angle theta is supplied by the user as a single continuous-value parameter, and controls the overall orientation that is enforced on the set of curves to be oriented. A "second preferred vector" v2 33 is calculated relative to v1 such that it is orthogonal to v1 and lies in the 2-dimensional plane occupied by the curve 34. The second preferred vector is used to resolve cases where the preferred vector yields an ambiguous solution. The direction of orthogonality (left orthogonal or right orthogonal in the 2-dimensional case) is not important provided that the same convention is used consistently. Note that if the second preferred vector is non-zero and linearly independent of the preferred vector, then ambiguity resolution is guaranteed. Alternatively, other types of non-zero linearly independent vectors may be used instead of orthogonal vectors.

For the general case of n-dimensional curves, n-1 additional preferred vectors are calculated from the initial preferred vector provided by the user, such that each successive preferred vector is non-zero and linearly independent of preceding preferred vectors, forming a basis.

For instance, Fig 4 shows a preferred vector set for a 3-dimensional example. There is shown v1 41, the initial preferred vector nominated by the user, v2 42 the second preferred vector that is orthogonal to v1, and v3 43 the third preferred vector that is orthogonal to both v1 and v2 44. The second preferred vector is used to resolve cases where the preferred vector gives an ambiguous solution, and the third preferred vector is used to resolve cases where the preferred and second preferred vectors both give ambiguous results. This chain of ambiguity resolution can be extended to n preferred vectors in n-dimensions as required. The preferred vectors need not be orthogonal to previous preferred vectors, but must be non-zero and linearly independent of previous preferred vectors. Any number of vectors may be specified (either linearly dependent or independent) provided that this set includes at least n linearly independent vectors.

Referring to Figs. 5A and 5B, there are illustrated two arrangements of the planar figure 21 based upon its end points A 22 and B 23 (Fig. 2). The first arrangement (Fig. 5A) shows the end points related by the vector BA 51, and the second arrangement (Fig. 5B) shows the end points related by the vector AB 52. This is one way to derive the "characteristic vector" based upon the curve's characteristics, and its "matching" vector, which in this case is co-linear with and in an opposite direction to the characteristic vector. Any algorithm that describes the curve in terms of a single characteristic vector may be applied, for instance integrating the curve to obtain the average direction vector.

Turning now to Figs. 6A and 6B, there are shown the angles alpha 61 and beta 62 given by the acute angle between vectors BA and v1, and vectors AB and v1 respectively. The relative magnitudes of angles alpha and beta define the final orientation of the curve, and can be conveniently calculated as the dot product of the vector pairs. If the magnitude of alpha is less that the magnitude of beta then the curve is described as being oriented "from B to A", and if the magnitude of alpha is greater than the magnitude of beta then the curve is described as being oriented "from A to B". Alternatively, the magnitude of alpha can be compared against a threshold of 90°. If

alpha is less than 90° the direction of the curve is "from B to A". If alpha is greater than the 90° threshold then the direction of the curve is "from A to B".

In the case that alpha and beta are of equal magnitude (the dot product is 0 in both cases), then the second preferred vector v2 can be used to resolve this ambiguity, as shown in Figs. 7A to 7F. The end points of the 2-dimensional curve 70 are related by the vectors DC 71 and CD 70, but the acute angles alpha 74 and beta 75 formed by these vectors and the preferred vector v1 are identical (both give a dot product of 0). The second preferred vector v2 is now used as follows. The acute angles gamma 76 and delta 77 formed by the vectors DC and CD and v2 are calculated, and their relative magnitude is used to determine the curve's orientation in a manner similar to the comparison between alpha and beta. That is, if the magnitude of gamma is less that the magnitude of delta then the curve is described as being oriented "from D to C", and if the magnitude of gamma is greater than the magnitude of delta then the curve is described as being oriented "from C to D". For the 2-dimensional case, if alpha and beta are of equal magnitude then it is not possible for gamma and delta to also be of equal magnitude. Alternatively, the magnitude of gamma can be compared against a threshold of 90°. If gamma is less than 90° the direction of the curve is "from D to C". If gamma is greater than the 90° threshold then the direction of the curve is "from C to D".

For the general case of an n-dimensional curve, the coordinates of the difference vector AB in the basis formed by the set of linearly independent preferred vectors is non zero when A is not equal to B. Here, the process is to choose the orientation "from A to B" if the first non-zero coordinate is positive, and choose the orientation "from B to A" if the first non-zero coordinate is negative. It is not possible for all n linearly dependent preferred vector comparisons to be ambiguous.

Turning now to Fig. 8, there is shown a closed curve 81, a special case of finite curve with no clearly defined start or end point. In this instance, either it can be decided that the orientation process applies only to open curves, or a second non-

ambiguous technique can be chosen to deal with this case. One example of such a non-ambiguous technique follows.

Given that the only restriction on end points is that all curve points must lie within the interval described by them, then any point on the closed curve may be chosen such that the start point A and end point B are coincident at this chosen point 82. Given no other criteria, it is sensible to choose as this coincident start/end position a point on the curve whose outward normal is most similar to the preferred vector v1 83. Alternatively, the point to be nominated as the coincident start/end point may be chosen randomly along the curve interval, pseudo-randomly for reproducibility, or according to some other relevant criteria. The vectors AB and BA in this case have no length or direction, however alternative vectors AB' 85 and BA' 86 can be defined tangent to the curve at point A/B and heading in opposite directions. Once AB' and BA' have been defined, the same algorithm as previously described for determining orientation in the non-closed case applies. Note that in this particular example, AB' and BA' are perpendicular to v1, so v2 will be the deciding vector here.

Turning now to Fig. 9, there is shown five different sets of stroke curves. The first curve set 900 to 905 illustrates a group of complex curves represent the character "S". The second curve set 910 to 915 illustrates a single curve of the character "S". The third curve set 920 to 925 represents an asterisk-like character. The fourth curve set 930 to 935 represents a group of complex curves representing the character "I". The fifth curve set 940 to 945 represents a group of complex curves representing the character "Q". Also shown is the direction of the preferred vector v_1 measured in degrees (950 to 955) in an anti-clockwise direction from the "9 o'clock" position. The direction of each of the stroke curves of Fig. 9 are shown for each direction of the preferred vector utilising the method described with reference to Figs. 5A to 7F.

<u>Further Examples</u>

Turning initially to Fig. 10, there is shown a sample 2-dimensional curve describing the path of the character "S" 101. Two end points A 102 and B 103 have

been labelled, and the curve is not oriented at this stage. The end points are selected such that all points along the curve lie within the interval formed by these end points. The outwardly directed end tangent associated with end point A, Ta 104, and the outwardly directed end tangent associated with end point B, Tb 105, are also shown. The tangent direction at end points can be calculated by standard mathematical techniques. This is only one way in which the dual "characteristic vectors" Ta and Tb may be calculated. Any algorithm that describes the curve in terms of a dual characteristic vector pair may be applied, for instance integrating the curve to obtain the weighted average direction vector relative to each end.

Turning to Fig. 11, there is shown the "preferred vector" v1 111 that describes an angle theta 112 with the X-axis. The angle theta is supplied by the user as a single continuous-value parameter, and controls the overall orientation that is enforced on the set of curves to be oriented.

Referring to Figs. 12A and 12B, there are shown the angles alpha 121 and beta 122 given by the acute angle between vectors Ta and v1, and vectors Tb and v1 respectively. The relative magnitudes of angles alpha and beta define the final orientation of the curve, and can be conveniently calculated as the dot product of the vector pairs. If the magnitude of alpha is less that the magnitude of beta then the curve is described as being oriented "from B to A", and if the magnitude of alpha is greater than the magnitude of beta then the curve is described as being oriented "from A to B".

Turning now to Fig. 13, there is shown the special case 131 where alpha and beta are of equal magnitude (end tangent vectors Ta 132 and Tb 133 are parallel). An additional technique can be used to resolve this ambiguity, similar to that described with reference to and illustrated in Figs. 5A and 5B. This technique is described in more detail with reference to Figs. 14A to 14D. The end points A 141 and B 142 of the 2-dimensional curve 140 are connected by the vectors AB 143 and BA 144. The angles alpha 146 and beta 147 are given by the acute angle between vectors AB and v1, and vectors BA and v1 respectively. If the magnitude of alpha is less that the magnitude of beta then the curve is described as being oriented "from B to A", and if

the magnitude of alpha is greater than the magnitude of beta then the curve is described as being oriented "from A to B". Alternatively, the magnitude of alpha can be compared against a threshold of 90°. If alpha is less than 90° the direction of the curve is "from B to A". If alpha is greater than the 90° threshold then the direction of the curve is "from A to B".

Illustrated in Figs. 15A to 15F is the case where alpha 146 and beta 147, of the previous example (Figs. 14C and 14D), are identical (both give a dot product of 0). In this case, both alpha 146 and beta 147 are right angles. A "second preferred vector" v2 150 is used to solve the ambiguity. The second preferred vector v2 150 is selected relative to v1 145 such that it is non-zero and linearly independent of v1 and lies in the 2-dimensional plane occupied by the curve 140. The second preferred vector v2 is used to resolve cases where the preferred vector v1 yields an ambiguous solution. For convenience, v2 is defined to be orthogonal to v1 where direction of orthogonality (left orthogonal or right orthogonal in the 2-dimensional case) is not important provided that the same convention is used consistently. Note that if the second preferred vector is non-zero and linearly independent of the preferred vector, then ambiguity resolution is guaranteed. The second preferred vector v2 150 is used as follows. The angles gamma 151 and delta 152 formed by the vectors AB and BA and v2 are calculated, and their relative magnitude is used to determine the curve's orientation similar to the comparison between alpha and beta. That is, if the magnitude of gamma γ is less than the magnitude of delta then the curve is described as being orientated "from B to A", and if the magnitude of gamma γ is greater than the magnitude of delta, then the curve is described as being orientated "from A to B". For the 2-dimensional case, if alpha and beta are equal in magnitude then it is not possible for gamma and delta to also be of equal magnitude. Alternatively, the magnitude of gamma can be compared against a threshold of 90°. If gamma is less than 90° the direction of the curve is "from B to A". If gamma is greater than the 90° threshold then the direction of the curve is "from A to B".

Turning now to Fig. 16, there is shown a closed curve 161, a special case of finite curve with no clearly defined start or end point. In this instance, either it can be decided that the orientation process applies only to open curves, or a second non-ambiguous technique can be chosen to deal with this case. One example of such a non-ambiguous technique follows.

Given that the only restriction on end points is that all curve points must lie within the interval described by them, then any point on the closed curve may be chosen such that the start point A and end point B are coincident at this chosen point 162. Given no other criteria, it is sensible to choose as this coincident start/end position a point on the curve whose outward normal is most similar to the preferred vector v1 163. Alternatively, the point to be nominated as the coincident start/end point may be chosen randomly along the curve interval, pseudorandomly for reproducibility, or according to some other relevant criteria. The end tangent vectors Ta 165 and Tb 166 are calculated, and the same algorithm as previously described for determining orientation in the non-closed case applies. Note that in this particular example, Ta and Tb are perpendicular to v1, so v2 will be the deciding vector here.

Referring to Fig. 17, there are shown a variety of character shapes described by 2-dimensional stroke paths similar to that shown in Fig. 9. However, in this case, the direction of the preferred vector v1 is measured anti-clockwise from a "3 o'clock" position. Furthermore, the method utilised for orientating the stroke curves is that described with reference to Figs. 11 to 15F.

If a curve to be oriented is already in an oriented format (that is, it occupies a monotonically increasing interval) then either:

a) the original direction can be retained, or

b) the curve must be reoriented,

depending on the outcome of the orientation algorithm. If the curve is to be reoriented, this can in general be achieved by relabelling the end points, reversing or reparamaterising the curve along its interval, or performing whatever action is relevant to the curve's specific format.

Preferred Embodiment of Apparatus(s)

The preferred method is preferably practiced using a conventional general-purpose computer, such as the one shown in Fig. 18, wherein the processes of Figs. 1 to 17 may be implemented as software executing on the computer. In particular, the steps of the method are effected by instructions in the software that are carried out by the computer. The software may be divided into two separate parts; one part for carrying out the orientation method; and another part to manage the user interface between the latter and the user. The software may be stored in a computer readable medium, including the storage devices described below, for example. The software is loaded into the computer from the computer readable medium, and then executed by the computer. A computer readable medium having such software or computer program recorded on it is a computer program product. The use of the computer program product in the computer preferably effects an advantageous apparatus for orientating a character stroke or n-dimensional finite space curves in accordance with the embodiments of the invention.

The computer system 1800 consists of the computer 1802, a video display 1816, and input devices 1818, 1820. In addition, the computer system 1800 can have any of a number of other output devices including line printers, laser printers, plotters, and other reproduction devices connected to the computer 1802. The computer system 1800 can be connected to one or more other computers via a communication interface 1808c using an appropriate communication channel 1830 such as a modem communications path, a computer network, or the like. The computer network may include a local area network (LAN), a wide area network (WAN), an Intranet, and/or the Internet

The computer 1802 itself consists of a central processing unit(s) (simply referred to as a processor hereinafter) 1804, a memory 1806 which may include random access memory (RAM) and read-only memory (ROM), input/output (IO) interfaces 1808, a video interface 1810, and one or more storage devices generally represented by

a block 1812 in Fig. 1. The storage device(s) 1812 can consist of one or more of the following: a floppy disc, a hard disc drive, a magneto-optical disc drive, CD-ROM, magnetic tape or any other of a number of non-volatile storage devices well known to those skilled in the art. Each of the components 1804 to 1812 is typically connected to one or more of the other devices via a bus 1814 that in turn can consist of data, address, and control buses.

The video interface 1810 is connected to the video display 1816 and provides video signals from the computer 1802 for display on the video display 1816. User input to operate the computer 1802 can be provided by one or more input devices 1808. For example, an operator can use the keyboard 1818 and/or a pointing device such as the mouse 120 to provide input to the computer 1802.

The system 1800 is simply provided for illustrative purposes and other configurations can be employed without departing from the scope and spirit of the invention. Exemplary computers on which the embodiment can be practiced include IBM-PC/ATs or compatibles, one of the Macintosh (TM) family of PCs, Sun Sparcstation (TM), or the like. The foregoing are merely exemplary of the types of computers with which the embodiments of the invention may be practiced. Typically, the processes of the embodiments, described hereinafter, are resident as software or a program recorded on a hard disk drive (generally depicted as block 1812 in Fig. 18) as the computer readable medium, and read and controlled using the processor 1804. Intermediate storage of the program and pixel data and any data fetched from the network may be accomplished using the semiconductor memory 1806, possibly in concert with the hard disk drive 1812.

In some instances, the program may be supplied to the user encoded on a CD-ROM or a floppy disk (both generally depicted by block 1812), or alternatively could be read by the user from the network via a modem device connected to the computer, for example. Still further, the software can also be loaded into the computer system 100 from other computer readable medium including magnetic tape, a ROM or integrated circuit, a magneto-optical disk, a radio or infra-red transmission channel

between the computer and another device, a computer readable card such as a PCMCIA card, and the Internet and Intranets including email transmissions and information recorded on websites and the like. The foregoing are merely exemplary of relevant computer readable mediums. Other computer readable mediums may be practiced without departing from the scope and spirit of the invention.

The preferred method of orientation may alternatively be implemented in dedicated hardware such as one or more integrated circuits performing the functions or sub functions of the steps of the method. Such dedicated hardware may include graphic processors, digital signal processors, or one or more microprocessors and associated memories.

The foregoing only describes a small number of embodiments of the present invention, however, modifications and/or changes can be made thereto by a person skilled in the art without departing from the scope and spirit of the invention.

The following numbered paragraphs set forth aspects of the invention, including:

1. A method of orientating a character stroke, the method including the following steps:

(i) selecting a desired direction in response to user input;

(ii) generating a second vector having an associated direction in the same direction as the selected direction;

(iii) providing a character stroke;

(iv) generating at least one first vector having an associated direction indicative of a characteristic of the character stroke;

(v) determining that direction of the character stroke nearest to said desired direction in accordance with said first and second vectors; and

(vi) orientating said character stroke to the determined direction.

2. A method as set forth in paragraph 1, wherein said step (iii) includes the following substeps:

(iii)(a) determining endpoints of said stroke; and

(iii)(b) generating one or two said first vectors, each connecting both said endpoints.

3. A method as set forth in paragraph 2, wherein said generation step (iii)(b) includes generating two said first vectors having opposite directions.

4. A method as set forth in paragraph 3, wherein said direction determination step (v) includes the following sub-steps;

(v)(a) determining a first angle between a first selected one of said first vectors and said second vector;

(v)(b) determining a second angle between a second selected one of said first vectors and said second vector, wherein said second selected vector is different from the first selected vector;

(v)(c) comparing said first angle with said second angle; wherein if said first angle is less than said second angle then the determined direction of the character stroke is in a first direction, and if said first angle is greater than said second angle then the determined direction of the character stroke is in a second direction, opposite the first direction.

5. A method as set forth in paragraph 2, wherein said at least one first vector comprises one said first vector and the direction determination step (v) includes the following sub-steps:

(v)(a) determining a first angle between said first vector and said second vector;

(v)(b) comparing said first angle with a first threshold value; wherein if said first angle is less than said first threshold value then the determined direction of the character stroke is in a first direction, and if said first angle is greater than said first threshold value then the determined direction of the character stroke is in a second direction, opposite the first direction.

6. A method as set forth in paragraph 5, wherein said first threshold value is 90°.

7. A method as set forth in any one of paragraphs 1 to 6, wherein said step (iv) includes the following substep:

(iv)(a) generating one or more said second vectors orthogonal to the first said second vector.

8. A method as set forth in paragraph 7, wherein said orthogonal second vectors are generated in a predetermined manner.

9. A method as set forth in paragraph 7, wherein said orthogonal second vectors are generated in accordance with one or more user selected directions.

10. A method as set forth in any one of paragraphs 7 to 9 where dependent on paragraph 4, wherein, if said first angle equals said second angle, the direction determination step further includes the following sub-steps:

(v)(d) determining a third angle between said first selected one of said first vectors and a said orthogonal second vector;

(v)(e) determining a fourth angle between said second selected one of said first vectors and a said orthogonal second vector;

(v)(f) comparing said third angle with said fourth angle, wherein if said third angle is less than said fourth angle then the determined direction of the character stroke is in a third direction, and if said third angle is greater than said fourth angle then the determined direction of the character stroke is in a fourth direction, opposite the third direction.

11. A method as set forth in any one of paragraphs 7 to 9 where dependent on paragraph 5 or 6, wherein, if said first angle equals said first threshold value, the direction determination step (v) includes the following sub-steps:

(v)(c) determining a second angle between said first vector and a said orthogonal second vector;

(v)(d) comparing said second angle with a second threshold value; wherein if said second angle is less than said second threshold value then the determined direction of the character stroke is in a third direction, and if said second angle is greater than said second threshold value then the determined direction of the character stroke is in a fourth direction, opposite the third direction.

12. A method as set forth in paragraph 11, wherein said second threshold value is

90°.

13. A method as set forth in paragraph 1, wherein said step (iii) includes the following substeps:

(iii)(a) determining endpoints of said stroke; and

(iii)(b) generating, at each said endpoint, a said first vector tangent to said stroke.

14. A method as set forth in paragraph 13, wherein said direction determination step (v) includes the following sub-steps;

(v)(a) determining a first angle between a first selected one of said first vectors and said second vector;

(v)(b) determining a second angle between a second selected one of said first vectors and said second vector, wherein said second selected vector is different from the first selected vector;

(v)(c) comparing said first angle with said second angle; wherein if said first angle is less than said second angle then the determined direction of the character stroke is in a first direction, and if said first angle is greater than said second angle then the determined direction of the character stroke is in a second direction, opposite the first direction.

15. A method as set forth in any one of claims 14, wherein, if said first angle equals said second angle, said step (iii) further includes the sub-step

(iii)(c) generating one or two said third vectors, each connecting both said endpoints.

16. A method as set forth in paragraph 15, wherein said generation step (iii)(c) includes generating two said third vectors having opposite directions.

17. A method as set forth in paragraph 16, wherein said direction determination step (v) further includes the following sub-steps;

(v)(d) determining a third angle between a first selected one of said third vectors and said second vector;

(v)(e) determining a fourth angle between a second selected one of said third vectors and said second vector, wherein said second selected vector is different from the first selected vector;

(v)(f) comparing said third angle with said fourth angle; wherein if said third angle is less than said fourth angle then the determined direction of the character stroke is in a third direction, and if said third angle is greater than said fourth angle then the determined direction of the character stroke is in a fourth direction, opposite the third direction.

18. A method as set forth in paragraph 15, wherein said at least one third vector comprises one said third vector and the direction determination step (v) includes the following sub-steps:

(v)(d) determining a third angle between said third vector and said second vector;

(v)(e) comparing said third angle with a first threshold value; wherein if said third angle is less than said first threshold value then the determined direction of the character stroke is in a third direction, and if said third angle is greater than said first threshold value then the determined direction of the character stroke is in a fourth direction, opposite the third direction.

19. A method as set forth in paragraph 18, wherein said first threshold value is 90°.

20. A method as set forth in any one of paragraphs 15 to 19, wherein said step (iv) includes the following substep:

(iv)(a) generating one or more said second vectors orthogonal to the first said second vector.

21. A method as set forth in paragraph 20, wherein said orthogonal second vectors are generated in a predetermined manner.

22. A method as set forth in paragraph 20, wherein said orthogonal second vectors are generated in accordance with one or more user selected directions.

23. A method as set forth in any one of paragraphs 20 to 22 where dependent on paragraph 17, wherein, if said third angle equals said fourth angle, the direction determination step further includes the following sub-steps:

(v)(g) determining a fifth angle between said first selected one of said third vectors and a said orthogonal second vector;

(v)(h) determining a sixth angle between said second selected one of said third vectors and a said orthogonal second vector;

(v)(i) comparing said fifth angle with said sixth angle, wherein if said fifth angle is less than said sixth angle then the determined direction of the character stroke is in a fifth direction, and if said fifth angle is greater than said sixth angle then the determined direction of the character stroke is in a sixth direction, opposite the fifth direction.

24. A method as set forth in any one of paragraphs 20 to 22 where dependent on paragraph 18 or 19, wherein, if said third angle equals said first threshold value, the direction determination step (v) includes the following sub-steps:

(v)(f) determining a fourth angle between said third vector and a said orthogonal second vector;

(v)(g) comparing said fourth angle with a second threshold value; wherein if said fourth angle is less than said second threshold value then the determined direction

of the character stroke is in a fourth direction, and if said fourth angle is greater than said second threshold value then the determined direction of the character stroke is in a fifth direction, opposite the fourth direction.

25. A method as set forth in paragraph 24, wherein said second threshold value is 90°.

26. A method as set forth in paragraph 1, wherein the method includes the step of providing further character strokes and performing the steps (v) to (vi) on each character stroke.

27. A method as set forth in paragraph 1, wherein the method includes a plurality of techniques for generating the first vectors and a step for selecting one of said techniques in response to user input.

28. A method of orientating a finite n-dimensional space curve, the method including:

(i) selecting a desired direction in response to user input;

(ii) generating one or more second vectors based on the selected direction;

(iii) providing a said finite n-dimensional space curve;

(iv) generating one or more first vectors based upon the finite n-dimensional space curve;

(v) determining that direction of the finite n-dimensional space curve nearest to said desired direction in accordance with said first and second vectors; and

(vi) orientating said finite dimensional space curve to the determined direction.

29. An apparatus for orientating a character stroke, the apparatus including:

means for selecting a desired direction in response to user input;

means for generating a second vector having an associated direction in the same direction as the selected direction;

means for providing a character stroke;

means for generating at least one first vector having an associated direction indicative of a characteristic of the character stroke;

means for determining that direction of the character stroke nearest to said desired direction in accordance with said first and second vectors; and

means for orientating said character stroke to the determined direction.

30. An apparatus for orientating a finite n-dimensional space curve, the apparatus including:

means for selecting a desired direction in response to user input;

means for generating one or more second vectors based on the selected direction;

means for providing a said finite n-dimensional space curve;

means for generating one or more first vectors based upon the finite n-dimensional space curve;

means for determining that direction of the finite n-dimensional space curve nearest to said desired direction in accordance with said first and second vectors; and

means for orientating said finite dimensional space curve to the determined direction.

31. A computer program product including a computer readable medium having recorded thereon a computer program for orientating a character stroke, the computer program product including:

means for selecting a desired direction in response to user input;

means for generating a second vector having an associated direction in the same direction as the selected direction;

means for providing a character stroke;

means for generating at least one first vector having an associated direction indicative of a characteristic of the character stroke;

means for determining that direction of the character stroke nearest to said desired direction in accordance with said first and second vectors; and

means for orientating said character stroke to the determined direction.

32. A computer program product including a computer readable medium having recorded thereon a computer program for orientating a finite n-dimensional space curve, the computer program product including:

means for selecting a desired direction in response to user input;

means for generating one or more second vectors based on the selected direction;

means for providing a said finite n-dimensional space curve;

means for generating one or more first vectors based upon the finite n-dimensional space curve;

means for determining that direction of the finite n-dimensional space curve nearest to said desired direction in accordance with said first and second vectors; and

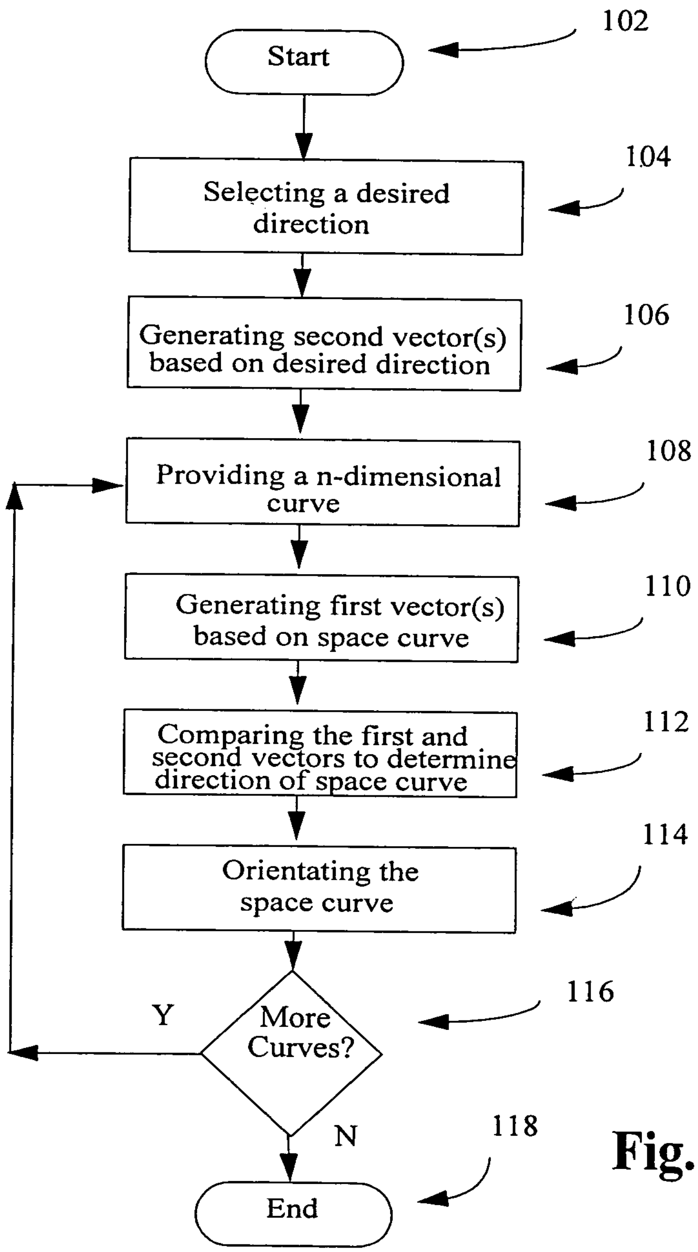
means for orientating said finite dimensional space curve to the determined direction.

DATED this TWENTY-EIGHTH day of AUGUST 1998

Canon Kabushiki Kaisha

Patent Attorneys for the Applicant

SPRUSON & FERGUSON



102
Start
104
Selecting a desired direction
106
Generating second vector(s) based on desired direction
108
Providing a n-dimensional curve
110
Generating first vector(s) based on space curve
112
Comparing the first and second vectors to determine direction of space curve
114
Orientating the space curve
116
Y
More Curves?
N
118
End

Fig. 1

Fig. 2

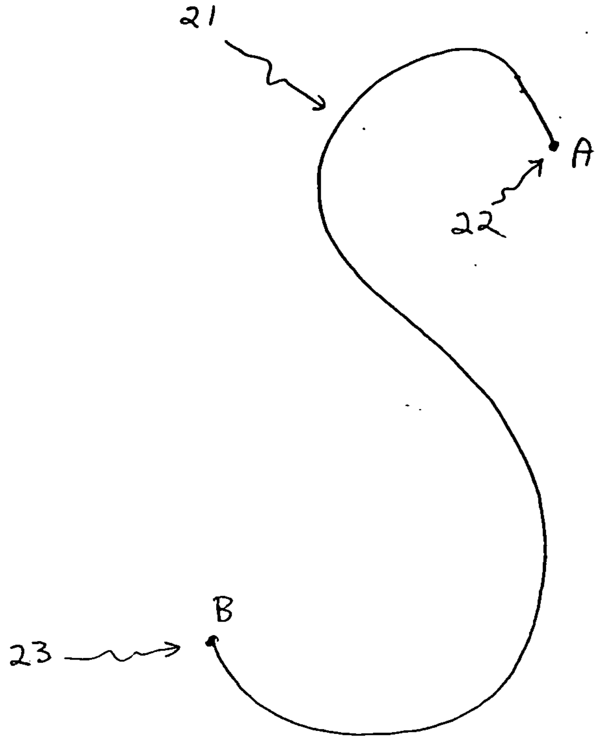


Fig. 3

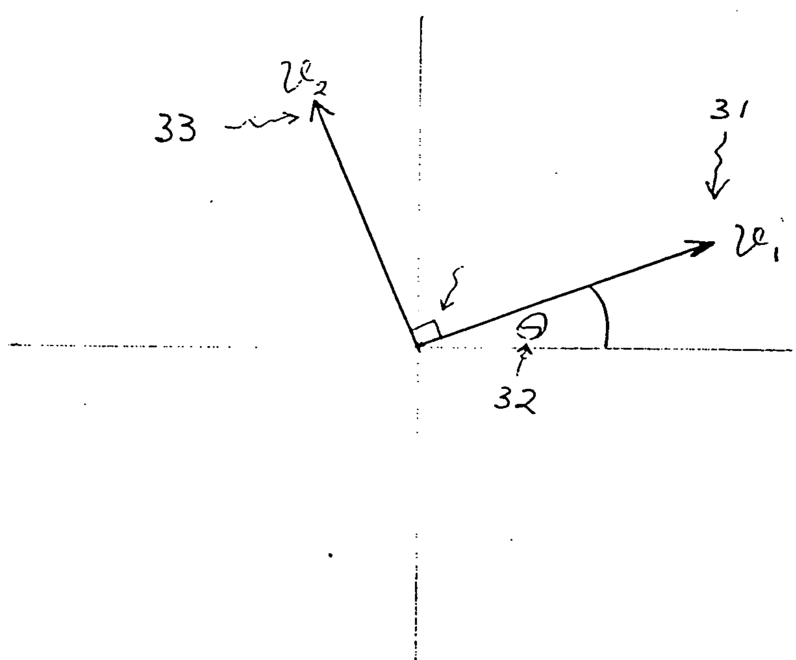
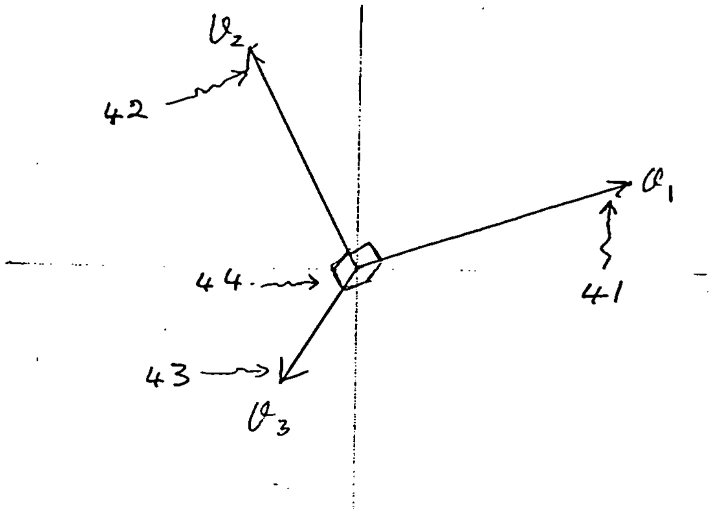


Fig. 4



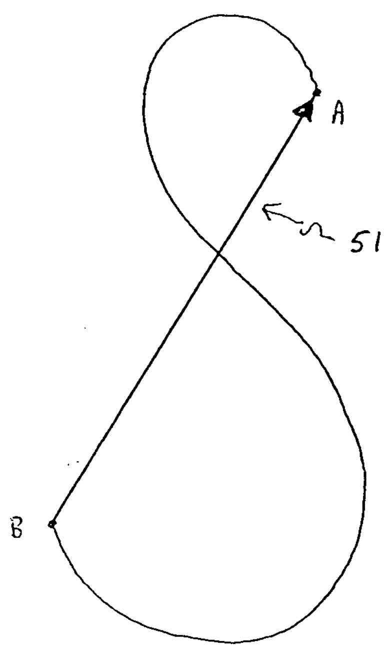


Fig. 5A

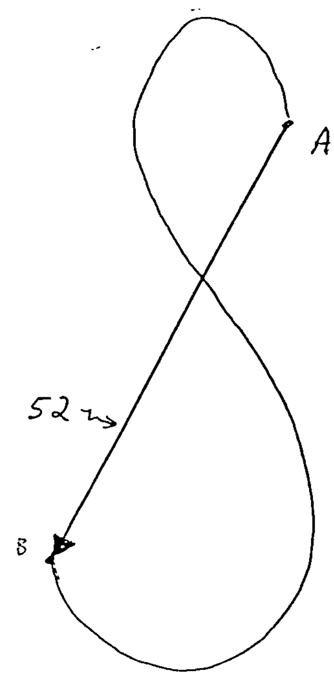


Fig. 5B

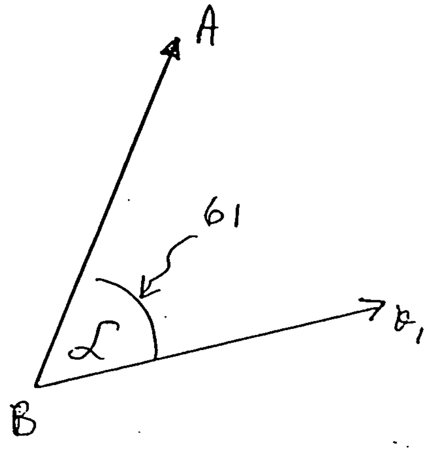


Fig. 6A

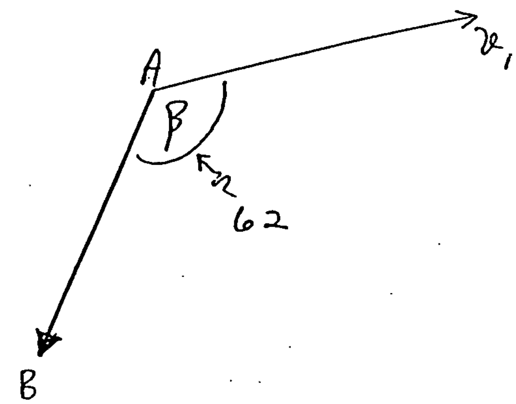


Fig. 6B

Fig. 7A

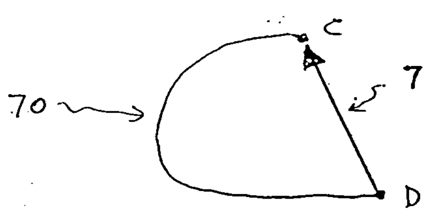
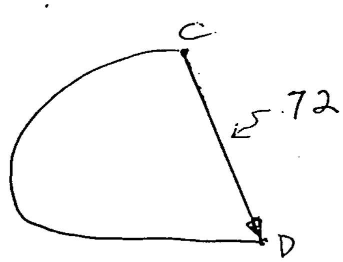


Fig. 7B



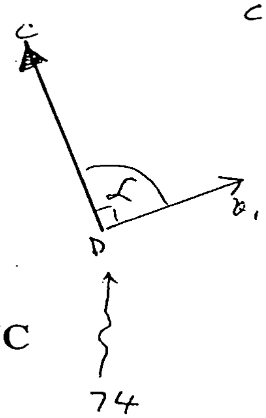


Fig. 7C

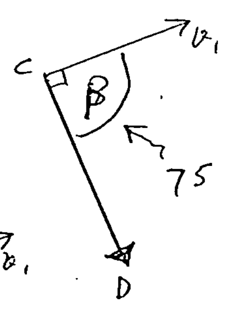


Fig. 7D

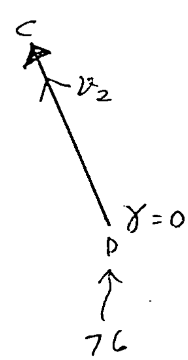


Fig. 7E

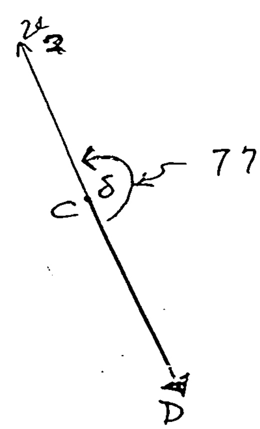


Fig. 7F

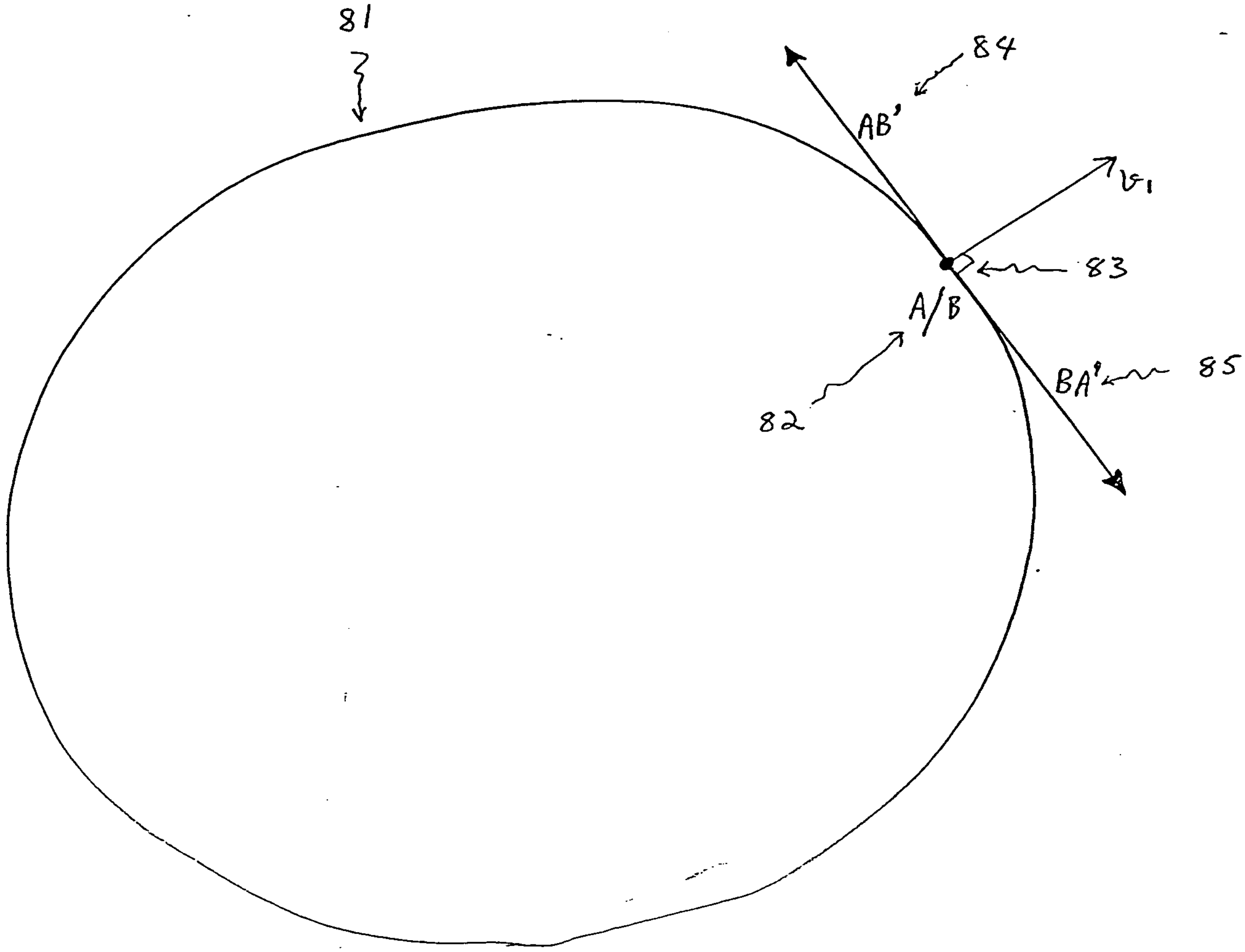
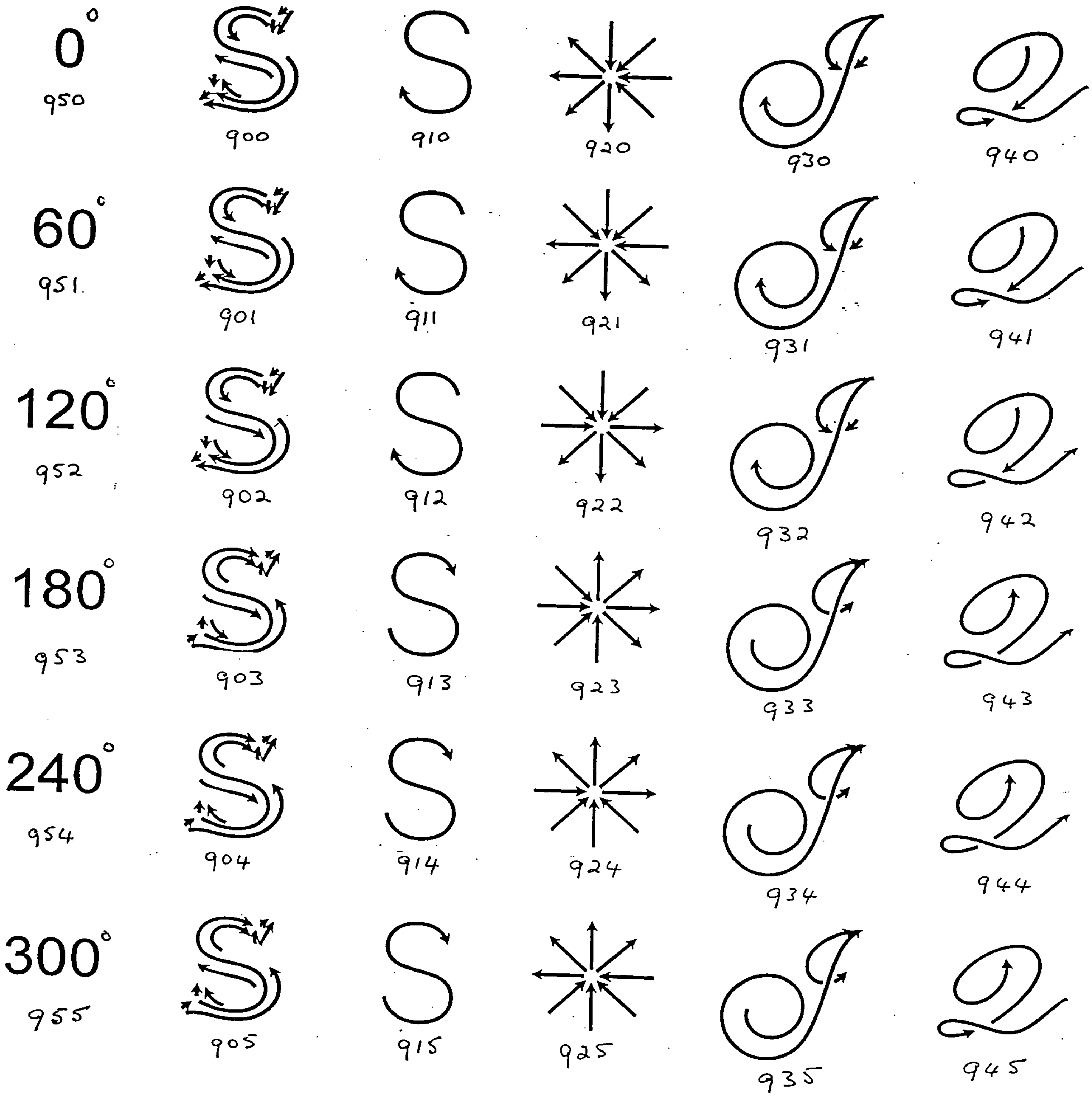


Fig. 8

Fig. 9


0°
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180°
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Fig. 10

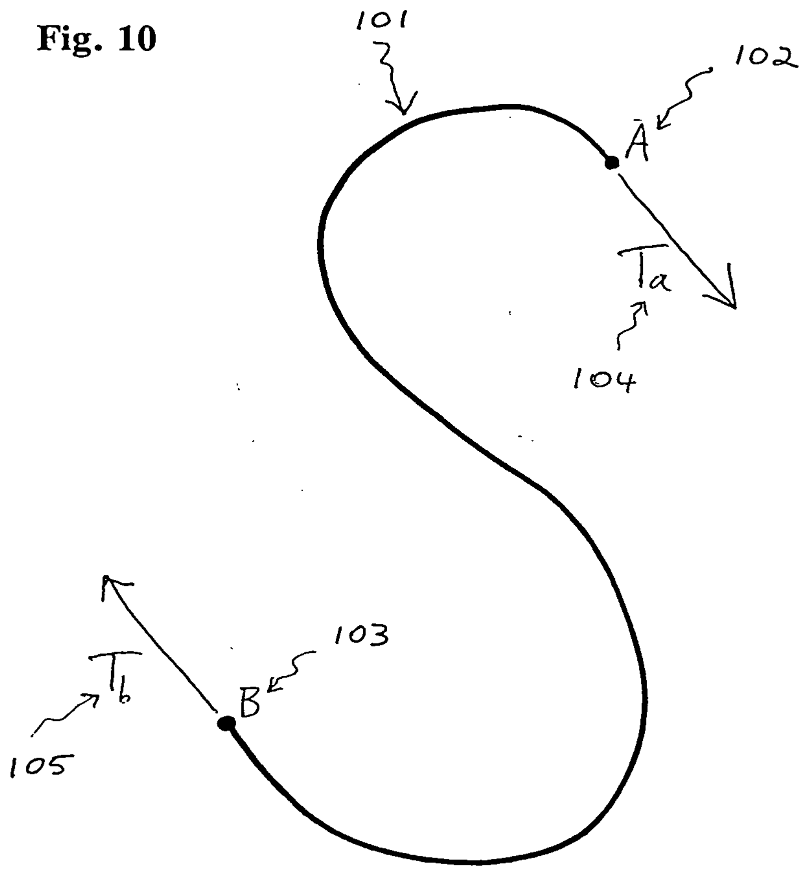
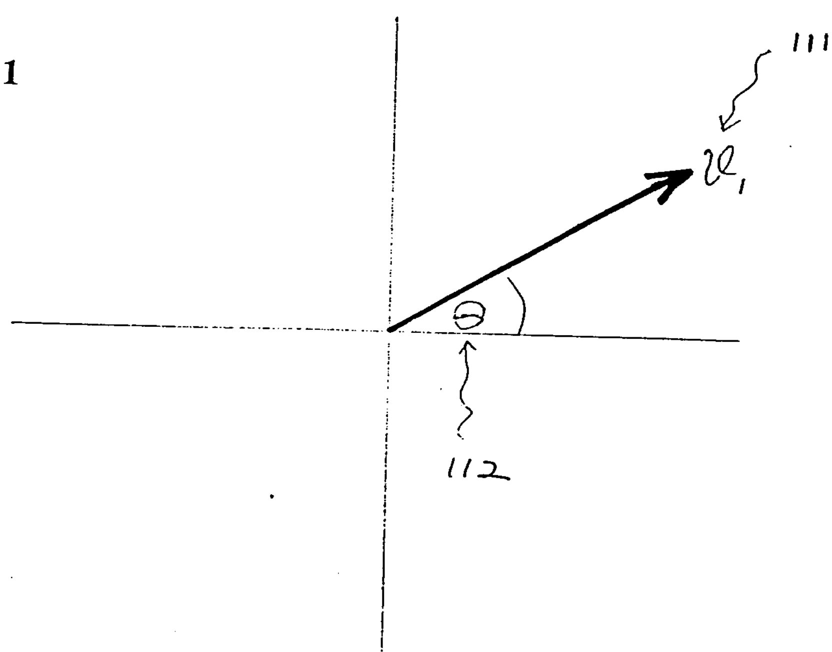


Fig. 11



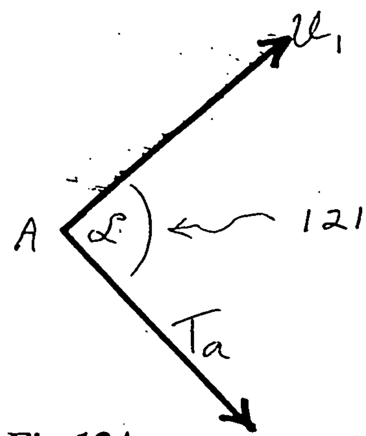


Fig.12A

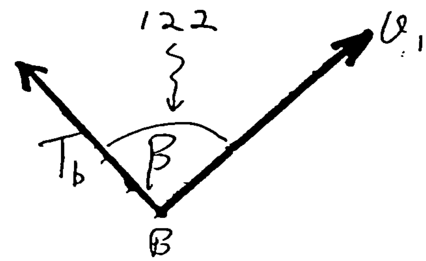


Fig. 12B

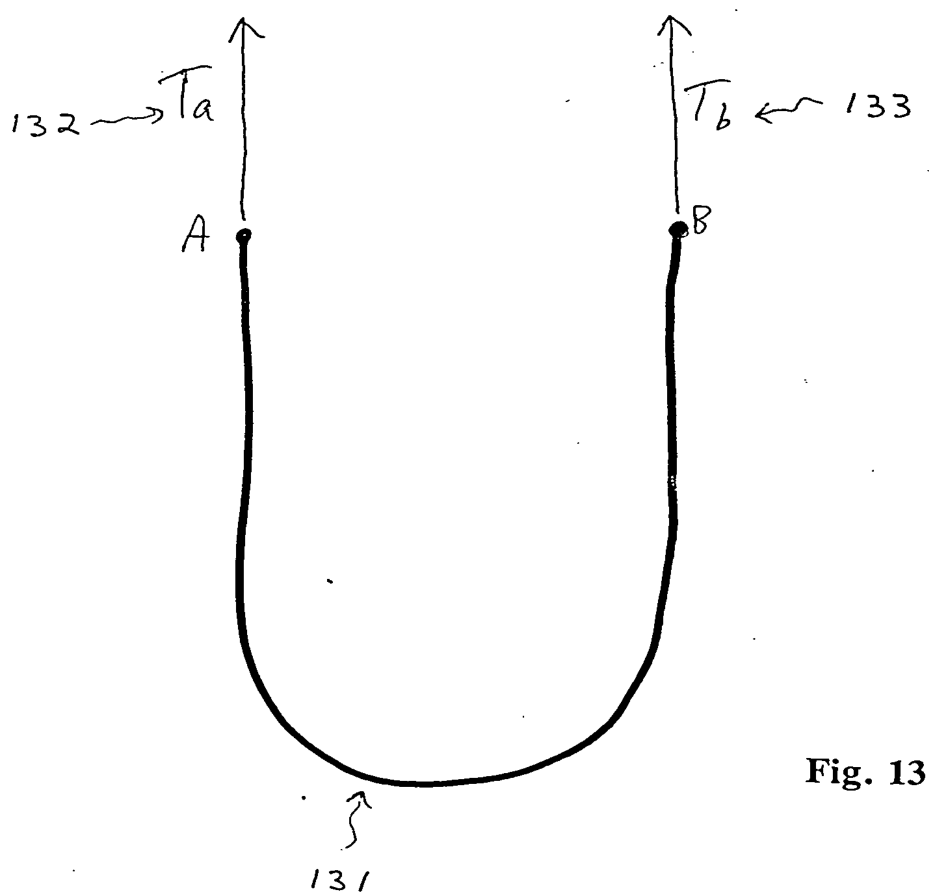


Fig. 13

Fig. 14A

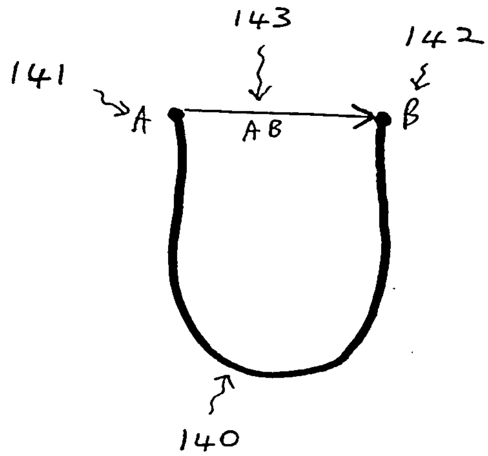
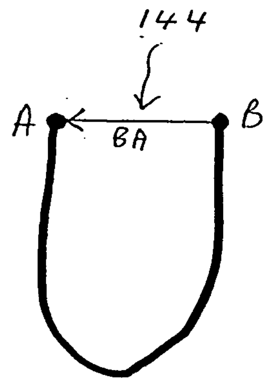


Fig. 14B



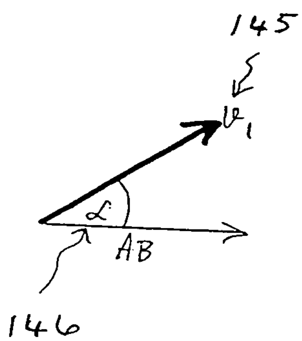


Fig. 14C

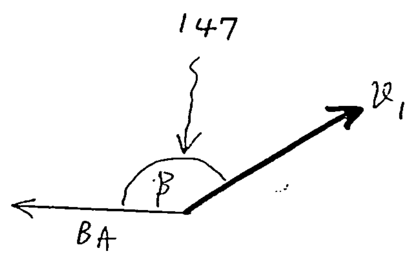


Fig. 14D

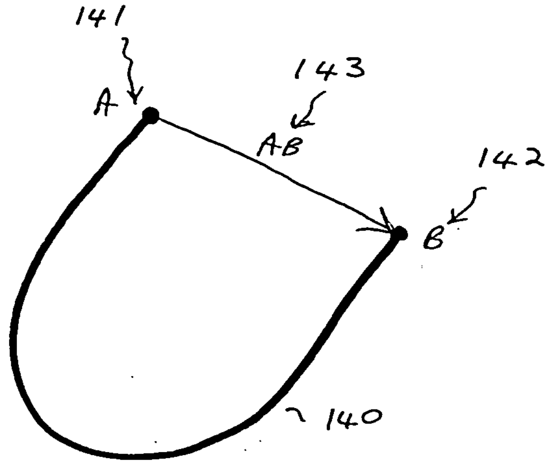


Fig. 15A

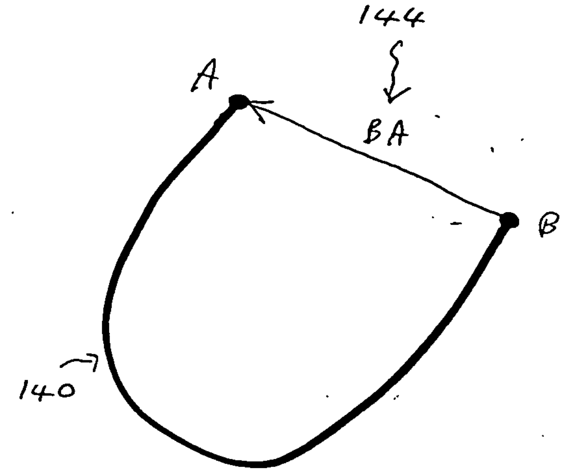


Fig. 15B

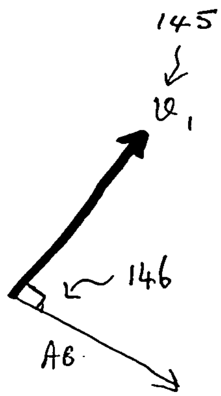


Fig. 15C

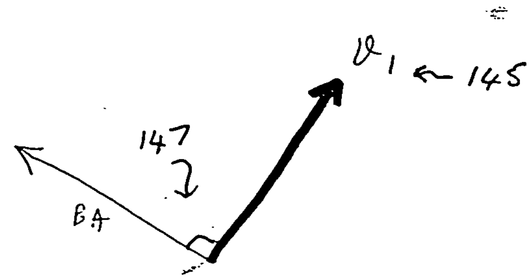


Fig. 15D

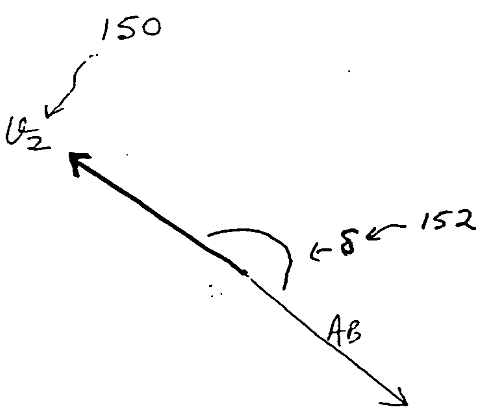


Fig. 15E

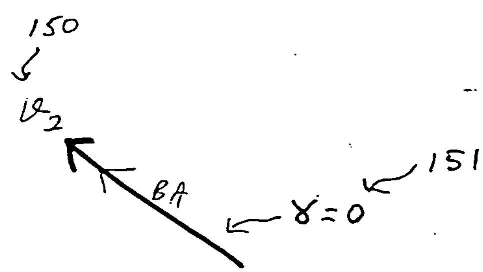


Fig. 15F

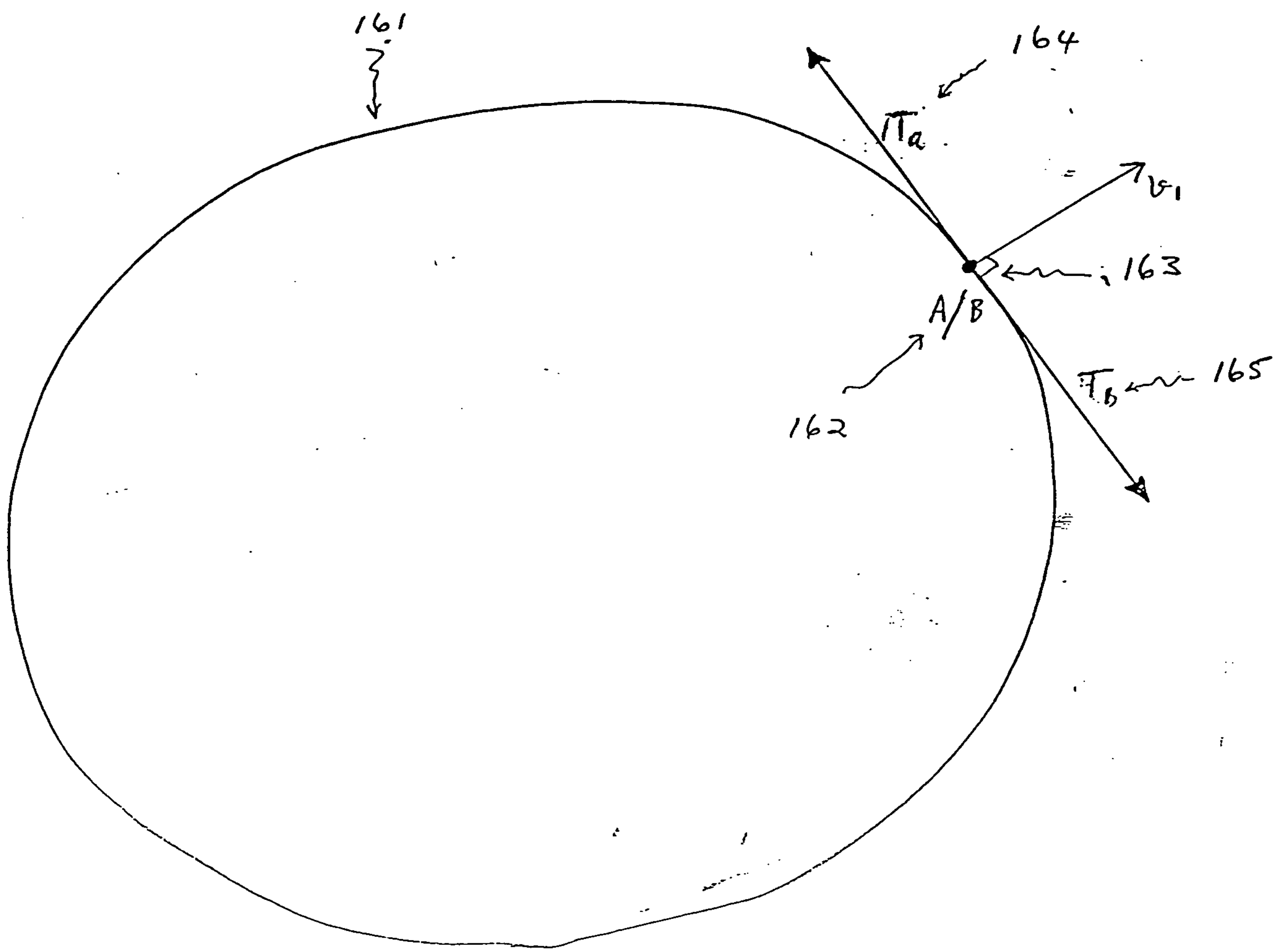


Fig. 16

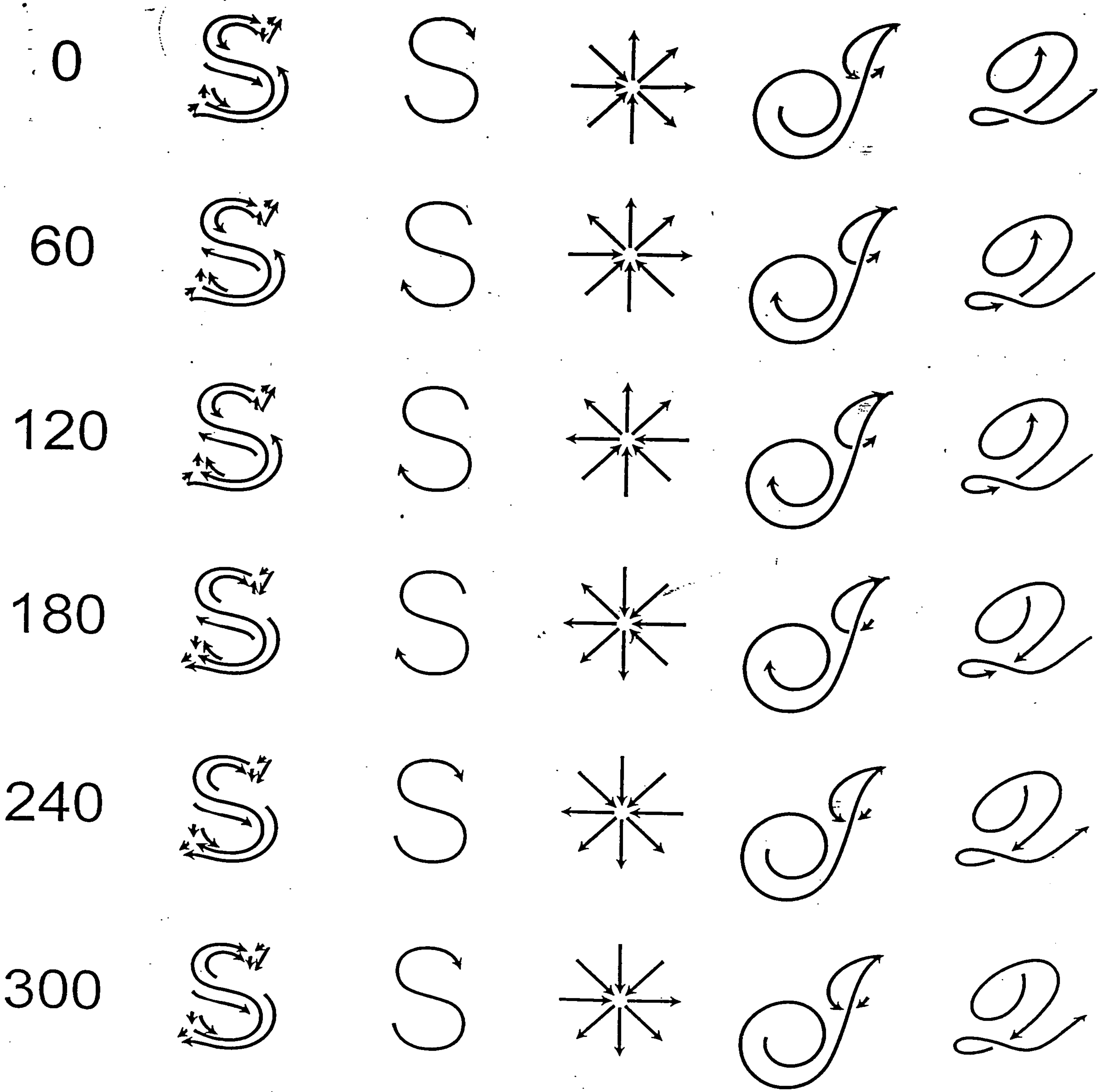
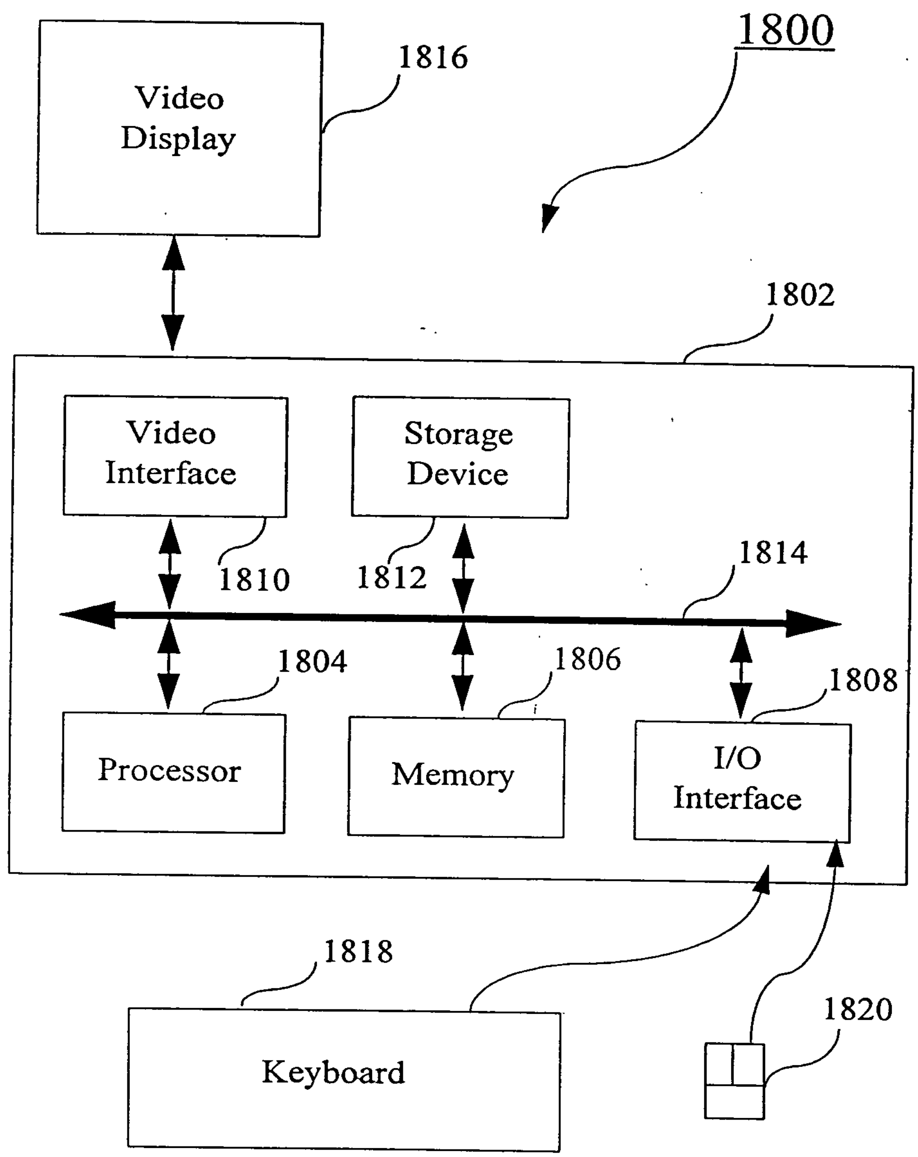


Fig. 17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Video Display
1816
1802
Video Interface
Storage Device
1810
1812
1814
1804
1806
1808
Processor
Memory
I/O Interface
1818
Keyboard
1820

Fig. 18